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PRELIMINARY RESULTS OF WATER QUALITY INVESTIGATIONS AT MENDENHALL PENINSULA AND AUKE BAY AREA, JUNEAU, ALASKA

By

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INTRODUCTION

Background

The present study was initiated in the winter of 1984. This water quality study is part of an overall investigation of ground water in the Mendenhall Peninsula - Auke Bay (MHP-AB) area, conducted by the water resources section of the Alaska Division of Geological 8 Geophysical Surveys. The impetus for these studies was a request from the Division of Land and Water Management for information and data on suspected saltwater contamination problems in the MHP-AB area. The information was also required to help adjudicate applications for groundwater usage by two proposed major developments in the area. The first of these was a housing complex on Fritz Cove Road; the second was the expansion of the Auke Bay small boat harbor facility. Both developments would Potentially draw relatively large volumes of ground water from fractured bedrock aquifers, thereby increasing the risk of saltwater intrusion. Concern was voiced by

property owners in the vicinity of the proposed developments because of the potential impact increased ground water usage could have on the yield and water quality of surrounding wells.

Aquifers for the area's wells are entirely within bedrock, mainly fractured greenstones, greenschists and pellitic rocks. Well depths are commonly about 200 ft and yields are low, typically 7-4 gpm. The ground water tends to be relatively high in dissolved solids. Several homeowner's, particularly those near beachfronts, reported experiencing deterioration of water quality over the past several years, apparently from saltwater intruding into the aquifers.

The water geochemistry study discussed in this report was designed as a reconnaissance effort to 1) help identify areas experiencing the greatest contamination problems; 2) distinguish and classify groundwaters from different aquifers; 3) determine the sources of wakers recharging the aquifers; and 4) establish a data baseline for monitoring and defining any future contamination that may result from continued development of the area.

Previous Studies

A study of water resources by Barnwell and Boning (1968) concentrated primarily on the Mendenhall Valley but also in-

included some data on the Mendenhall Peninsula Area and the area. Barnwell and Boning (1968) reported salt or brackish water occurences in deep wells in the central part of the valley and suggested that some of the saltwater may be connate or may have been left during depostion of valley-filling sediments. The single water analysis reported by them for the MHP-AB area is for a well in the vicinity of the University of Alaska, Juneau. The water produced from the 120 ft well was a Na-Ca-Mg bicarbonate water with no apparent sulfate or chloride contamination. Barnwell and Boning (1968) also reported yields of less than 1 gpm to 20 gpm and an average of 3 gpm based on sample of 46 wells producing from bedrock aquifers.

A more recent study of water quality in the MHP-AB area was undertaken by G. Balding of the USGS. Balding (1979) presented the results of his study of water supplies in the HHP-AB area in a report to the Division of Land and Water Management. His study was based on a questionaire sent to residents in the MHP-AB area and on measurements of specific conductance of waters from selected wells. Balding's work provided information on the locations and depths of many of the wells investigated in this study and also provided baseline specific conductance data. Balding's data suggested that problems with saltwater intrusion were already prevalent in 1979.

Scattered measurements of water quality and arsenic concen-

trations in well waters in the MHP-AB area have been made by DEC. These data have not been published but are on public file.

GEOLOGIC SETTING

Bedrock

Bedrock in the MHP-AB area consists of Tertiary and Cretaceous aged greenstones, greenschists, metaconglomerates, pelli tic rocks, metasandstones and metasiltstones (Ford and Brew, 1973) (fig. 1). The rocks are part of a southwest trending belt of metamorphic rocks with metamorphic-isograd increasing towards the northwest. The boundary between the greenschist facies and prehnite-pumpellyite metagraywacke facies lies just northwest of the MHP-AB area.

Bedrock on the Mendenhall Peninsula ranges from chiefly augite-rich metatuffs, originally basaltic to andesitic, in places mixed with metagraywacke, argillite, or slate on the west side of the peninsula to dark, volcanic-derived metasedimentary rocks on the east side (Ford and Brew, 1973). Bedrock exposed in the Auke Bay area is mostly argillite and slate.

Two sets of joint patterns occur in the MHP-AB area. The first set trends about 45° NE with dips ranging from 72° SW

to near vertical. The second set trends north-south with near vertical dip. Major faults in the area include the Gastineau Channel, Fish Creek, and Peterson Creek faults, all of which trend northwestward (fig. 1).

Surficial Deposits

Surficial deposits in the MHP-AB area consist primarily of the Gastineau Channel Formation, a composite glaciomarine deposit defined by Miller (1973; 1975) which occurs throughout the Gastineau Channel region. Exposures in the MHP-AB area (fig. 2) are predominately of the third (and youngest) of Miller's three facies: a light gray to greenish-gray massive to soft sandy diamicton containing unbroken and articulated molluskan shells and Foraminifera. Miller reported radiocarbon ages ranging from 9, 700 to 10, 700 years B. P. and thicknesses ranging from 4 to 12 ft for the third facies. The deposits in the Gastineau Channel region locally overlie bedrock but normally overlie deposits of the first facies.

The first facies, which is exposed at the northwest end of Mendenhall Peninsula, consists of gray to light-gray to greenish-gray generally hard, dense till-like stony diamicton, rich in mollusks and Foraminifera (Millar, 1975). The first facies overlies bedrock in most places in the Gastineau Channel region and ranges in thickness from 20 to greater than 60 ft.

Other surficial deposits in the MHP-AB area include raised beach deposits, rubble deposits, and fan deposits.

METHODS OF STUDY

Field Sampling

Locations of wells in the MHP-AB area are shown on plate 1. Time and funding limitations restricted the geochemical studies to sections 23 and 35, areas which were deemed most critical because of proposed developments. All sites for which chloride concentrations were measured during this study are also shown on plate 1. Whenever possible, measurements of static water level accompanied the geochemical sampling. However, not all wells for which static levels were measured were sampled for geochemical analyses.

Waters from 18 well sites were sampled, filtered, and treated for full cation and anion geochemical analysis (table 1). Alkalinity and pH on these waters were measured in the field, or shortly thereafter. Raw, unfiltered samples were obtained from ten additional well sites. No pH or alkalinity measurements were made on these samples. Five of the samples were analyzed for major cations and anions (except HCO3). The other five were analyzed for S04, Cl, F, and Br only. One site was checked for Cl only.

A cold water stream located on the southeast part of Mendenhall Peninsula was sampled and a complete cation - anion analysis was performed to provide for a comparison with ground water chemistries.

Waters from twenty-five different sites, including five streams and springs, were sampled and analyzed for deuterium, Analyses of $\delta^{18}O$ were made for 13 of these sites.

Wells were normally sampled after water was first run for about 5-10 minutes at a rate of about 0. 5 to 1 gpm. The sample was normally taken as close to wellhead as possible and always before any treatment or water softening system.

Methods of Analyses

Alkalinity as bicarbonate, pH, specific conductance and ammonia were determined in the field following methods described in Presser and Barnes (1974). The remaining constituents were analyzed at the DGGS water laboratory in Fairbanks. Major and minor cation concentrations were determined using a Perkin-Elmer atomic absorption spectrometer following standard procedures. Sulfate and bromide were determined on a Dionex ion chromatograph. Fluoride was determined using the specific ion electrode method. Chlorides were analyzed by Mohr titration and

boron, by carminic acid method. Aluminum, arsenic, and iron were determined by atomic absorbtion spectroscopy. A graphite furnace was used for arsenic determinations to enhance low-level detection. Silica concentrations were determined by the molybedinate blue method. Stable isotopes were analyzed at the Stable Isotope Laboratory at Southern Methodist University, Dallas, Texas.

RESULTS

Results of the geochemical analyses are presented in table 1, grouped by locality, and in table 2, grouped by proposed water types. Percent major cation and anion compositions for waters for which full analysis were run are plotted on a Piper diagram (fig, 3). The milliequivalent concentrations For these sites are plotted on plate 1. The Five samples for which all major constituents, except HC03, were analysed are also plotted. The HC03 concentrations for these samples were estimated by comparing cation - anion milliequivalent balances, The amount of additional milliequivalent anions required to balance the cation total was assumed to be HC03. For comparison, the percentage composition of seawater is plotted on the Piper diagram.

Three water types have been distinguished based on relative and absolute cation-anion composition (fig, 3 and table 2, respectively). Type 1 waters are high pH, Na - HC03 rich waters with relatively low concentrations of Ca and Mg and

varying amounts of SO4 and Cl. The increases in Cl (and possibly some of the SO4) is presumably due to varying degrees of saltwater contamination. The waters tend to have comparitively low concentrations of Sr, Fe, and As. Type 1 waters are located exclusively in section 35 and approximately southwest of a line running through 35-38 and 35-13.

Type 2 waters are found in section 23, Type 2 waters have concentrations of Na and HC03 similar to type 1 waters but have significantly greater concentrations of K, Ca, and Mg. Type 2 waters also tend to have lower pH and greater concentrations of Sr and sometimes Fe than type 1 waters. All type 2 waters sampled, except 23-28 and perhaps 23-05, suggest some degree of saltwater contamination as reflected by higher Cl concentrations. The most contaminated well, 23-01 (Cl= 950 ppm), lies close to the Auke Bay beachfront and is the primary water supply for an apartment complex. Two sites which show slightly elevated levels of Cl concentration, 23-14 and 23-05, are located some distance away from the beachfront (1500 ft) suggesting that saltwater intrusion from Auke Bay may not be the source of Cl contamination in the aquifers supplying these wells.

One of the sites, 23-24, has a SO4 concentration (790 ppm) significantly higher than any other sampled in the MHP-AB area. Type 2 waters are low in As, and, except for 23-05, low in Fe,

Type 3 waters are distinguished by having proportionately greater concentrations of both Ca and Mg, and lower pH than either type 1 or type 2 waters. The waters are rich in HC03 and, with the exception of 35-39, are comparitively low in SO4. Two type 3 waters for which full analyses are available show significant Cl contamination. Two other sites for which only partral analyses are available but are probably type 3 waters (35-32 and 35-08) also have high concentrations of Cl. All four of these sites are located near shorelines along the west side of Mendenhall Peninsula. Type 3 waters also tend to have greater concentrations of Fe or As or both than either type 1 or type 2 waters.

Three subcategories of type 3 waters are distinguishable based on cation composition and location. Type 3a waters have greater proportions of Na than Ca + Mg, low Cl and tend to be located inland. Type 3b waters are distinguished by high As concentrations and location in section 23. Type 3c waters have Ca t Mg greater than Na and, except for 35-20, are all located near shorelines.

Total dissolved solids (TDS) in samples for which full analyses are available range from 155 ppm (35-20) to 2086 ppm (23-01). However, based on the partial anion analysis available for site 35-08, the TDS in waters from some beachfront wells are likely to substantially exceed 2000 ppm.

For comparison, the TDS in waters sampled from the stream referenced as Mendenhall 1390 (35-54) are 17 ppm.

Table 3 gives the chloride concentrations of sites sampled ranked in order of decreasing concentration. Chloride concentrations range from 1720 ppm for site 35-08 to as low as 1 ppm for the stream at the Mendenhall 1390 site. Except for the samples with highest chloride concentrations, Na shows little correlation with increasing Cl (fig. 4). As can be seen from figure 5, high concentrations of Na are also associated with high concentrations of bicarbonate,

Table 4 gives arsenic concentrations of sites sampled ranked in order of decreasing concentration. Three sites are at or near the Department of Environmental Conservation's maximum allowable standard for drinking water of 50 ppb. One site, 23-31, is considerably above safe levels.

Results of analyses of stable isotope compositions are presented in tables 1 and 2 and in figures 6, 7, and 8. Deuterium compositions of well waters range from -90 to -100 per mil with respect to Standard Mean Ocean Water (SMOW) and are similar to deuterium compositions of locally derived meteoric waters (LDMW) (fig. 6). Samples for which 6180 compositions are available are plotted in figure 7. The meteoric water line of Craig (1961) and the Adak precipitation line (Motyka, 19821 are plotted for com-

parison Adak is the only coastal site in Alaska for which there is sufficient stable isotope data for determining a precipitation line. The MHP-A3 area waters tend to plot close to Craig's meteoric water line but a few samples appear slightly shifted towards more positive δ18O. The similarity between LDMW and the well-water stable isotope compositions indicates the water in the MHP-AB aquifers is re charged by meteoric waters that precipitates at low elevations,

The deuterium compositions of the well waters show a weak correlation with increasing Cl concentration. An increase in δD would be expected if sea water is the source of increased Cl in the well waters. The isotopic composition of Gastineau Channel saltwater is not known but is expected to be substantially lighter than SMOW because of the large influx of freshwater runoff from coastal mountains.

DISCUSSION

The geographic trend of ground-water types discussed above tend to cut across the trend of bedrock contacts. This is particular true of the type 1 Na-CO3 waters. Instead, the geographic trends in water chemistry tend to correlate with the primary fracture orientation of 45° NW.

The majority of the wells showing chloride contamination occur near shorelines indicating the contaminaton is

primarily due to saltwater from Auke Bay intruding into fractures in the aquifers. Two sites, however, are some distance away from the coast and for these sites the chloride contamination may orlginate from a different source. Auke lake, a remnant glacial lake, lies 700 ft, or less, east of the two suspect wells (23-74 and 23-05). If the aquifers feeding these two wells are being charged by waters infiltrating along northeast oriented fractures then some of the recharge waters may originate from Auke Lake.

Although the depth of Auke Lake is not known, it is probable that the Holocene glaciomarine deposition prevalent throughout the Gastineau Channel region also occurred at Auke Lake, In fact, judging by the large and rapid rate of isostatic rebound that has occurred throughout the Gastineau Channel region (Miller, 1973), Auke Lake may have been connected to saltwater in the recent past and the lake may still be saline at depth. In addition, if Auke Lake formed a depositional basin for marine sediments during postglacial times then a relatively large thickness of Qlaciomarine deposits could have accumulated within the basin and now underlies the lake. Percolation of lake waters through these sediments would leach salts and introduce them into subsurface aquifers. The high calcium and strontium levels present in the type 2 waters perhaps originates from decomposi ton of mollusk shells. These or similar marine beds could be a source of the high SO4 present in some of the MHP-AB area well waters.

Chloride concentrations for sites sampled are plotted on plate 1. Chloride concentrations less than 10 ppm indicate the well-water is not contaminated by saltwater. Concentrations over 50 ppm indicate incipient saltwater contamination and caution should be excersized before increasing the rate of extraction from the supplying aquifer. Concentrations between 100 and 500 ppm indicate saltwater contamination has occurred and no further stress should be placed on the aquifer, Concentrations over 500 ppm indicate saltwater contamination of the supplying aquifer is severe.

The similarity in isotopic composition of water from wells and LDMH indicates that the primary source of water recharging the bedrock aquifers is precipitation at relatively low elevations. For sites where saltwater intrusion is severe (Cl> 500 ppm), the heavier deuterium compositions reflect the mixing of a saltwater component with the meteoric recharge waters.

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APPENDIX

WATER ANALYSES REPORTS

Mendenhall Peninsula and Auke Bay

Part 1

Table 1. Preliminary geochemical analyses, Auke Bay - Mendenhall Peninsula, ordered by locality.

Site Name	Date Sampled	Map No.	Area	Well Depth, ft	T	pH (a)	Cations, ppm Na	K	Ca	Mg	Li	Sr
Olson	6-16-M	23-24	1	275	7	8.1	352	2.7	26.8	9.2	0.08	3.5
U. of Juneau	6-16-84	23-14	1	227	11	8.4	299	9.1	20.4	19.3	0.06	1.4
Bay View	6-14-M	23-01A	1	90	10	7.3	440	20.1	147.0	103.0	0.11	7.2
Ghea	6-14-84	23-20	2	73	7	8.4	139	8.5	5.2	2.9	0.02	0.3
Jones	6-19-M	23-05	2	145	7	7.7	93	6.5	29.3	8.0	0.01	0.5
Dehardt	6-14-84	23-08	2	290	12	7.5	179	6.1	29.3	15.5	0.05	2.2
Auke Bay	b-19-84	23-23	2	202	10	8.0	230	4.9	29.3	9.7	0.07	2.4
Trambitas	b-19-84	23-31	3	109	9	7.7	18	2.6	31.5	10.5	0.01	0.6
Coates	b-20-14	23-41	3	-	8	7.5	29	4.1	37.5	19.2	0.02	0.8
Auke Creek	t-15-84	23-44	4	-	14	-	-	-	-	-		-
Bay Creek	6-15-84	23-45	4	-	9	-	-	-	-	-		-
Lake Creek	6-15-84	23-46	4	-	9	-	-	-	-	-		-
Karenin	3-13-84	35-13	1	85	5	9.3	199	3.8	1.4	1.2	0.01	0.
Thomason	3-13-84	35-24	1	216	5	8.7	154	0.4	1.5	1.1	0.02	0.
Houlihan	2-22-84	35-15	1	260	5	-	276	0.8	2.7	2.5	0.02	-
Hursch	3-14-84	35-10	2	200	7	7.8	40	0.9	31.5	1.2	0.01	0.
Watts	2-02-84	35-28	2	200	7	-	84	1.6	19.8	6.5	0.01	-
Clasby	3-04-84	35-05	2	150	14	8.9	185	0.4	2.8	1.7	0.02	0.
Lamonica	5-02-84	35-53	2	200	9	7.3	17	4.6	166.0	17.0	0.04	1.
Meilke	2-01-84	35-38	2	220	9	-	277	2.5	4.2	2.6	0.03	-
Nash	5-03-84	35-48	3	80	6	-	-	-	-	-		
Buckley	5-02-M	35-12	3	87	6	-	-	-	-	-		
Mc Vey	3-22-84	35-39	3	89	12	7.2	40	7.7	140.0	33.4	0.06	
Cummings	2-07-84	35-09	3	212	6	-	171	1.2	16.2	8.5	0.02	
Johnson	5-02-84	35-52	3	475	9	-	-	-	-	-		
Bradley	3-14-84	35-03	3	95	8	7.9	98	5.0	24.0	14.8	0.03	
Argetsinger	2-01-84	35-02	3	115	7	-	132	24.0	211.0	92.0	0.09	
Keithahn			3	92	9	-	-	-	-	-		
Hagerup	5-02-84	35-08	3	129	8	-	-	-	-	-		
Ramsey	3-22-84	35-20	4	202	7	6.7	13	0.5	35.8	6.5	0.01	0.
Lundstrom	5-02-84	35-33	4	-	10	-	-	-	-	-	-	-
Palmer	5-03-84	35-43	4	93	7	7.5	44	2.7	47.0	25.8	0.02	0.
Beaver Springs	5-03-84	35-55	3	-	4	-	-	-	-	-	-	-
Mendenhall 1390	5-03-84	35-54	3	-	5	5.4	1	<0.5	3.5	1.0	<0.01	<0.

a) Measured a well water temperature.

Table 1. Preliminary geochemical analyses, Auke Bay - Mendenhall Peninsula, ordered by locality.

Site Name	Date Sampled	Anions, ppm CO3	HCO3	SO4	Cl	F	Br	Other, ppm SiO2	FE	B	NH4	NO3
Olson	b-lb-84	-	143	788	96	2.7	bd	6.6	0.08	-	-	tr
U. of Juneau	6-16-84	1.5	269	396	166	0.3	tr	15.0	0.20	-	-	bd
Bay View	b-14-84	-	241	292	944	0.3	tr	12.5	0.22	<0.50	-	0.
Chea	6-14-84	2.5	345	15	8	0.7	bd	8.2	0.10	<0.05	-	0.
Jones	b-19-84	-	286	39	53	0.1	bd	14.0	1.08	<0.50	-	bd
Oehardt	b-14-84	-	277	235	78	1.9	bd	9.0	0.12	<0.50	-	0.
Auke Bar	6-19-84	-	328	262	80	2.8	bd	7.8	0.04	0.60	-	tr
Trarbi tas	6-19-84	-	204	10	2	<0.1	bd	10.8	0.23	0.60	-	bd
Coates	6-20-84	-	260	35	10	.0	bd	15.0	0.69	<0.50		tr
Auke Creek	b-15-84	-	-	-				-	-			
Bay Creek	b-Z-84	-	-	-					-			-
Lake Creek	b-15-09	-	-	-	-	-	-	-	-			
Karenin	3-13-84	28.0	506	35	4	1.2	bd	6.2	0.18	0.83		bd
Thorason	3-13-84	6.0	346	57	4	0.7	bd	7.5	0.12	(0.50		bd
Houlihan	3-22-84	-	-	345	24	1.0	bd	7.3	-	0.80		bd
Hursch	3-14-84	-	210	19	2	<0.1	bd	10.5	0.23	<0.50		bd
Watts	2-02-84	-	-	22	2	0.4	bd	12.7	-	(0.50		bd
Clasby	3-04-84	6. 0	283	109	40	0.8	bd	7.7	0.15	(0.50		bd
Lamonica	5-02-84	-	334	62	153	tr	bd	16.0	1.02	<0.50		bd
Meilke	M-84	-	-	214	157	0.6	bd	10.8	-	0.50		tr
Nash	5-03-84	-	-	12	2	0.8	bd	-	-	-		tr
Buckley	5-K-84	-	-	73	4	0.3	bd	-	-			bd
Mc Vey	3-22-84	-	410	295	9	0.4	bd	26.0	1.28	<0.50	0.4	bd
Cummings	2-07-84	-	-	9	13	0.4	bd	19.0	-	<0.50		bd
Johnson	5-02-84	-	-	34	17	0.1	bd	-	-	<0.50		tr
Bradley	3-14-84	-	334	57	22	0.2	bd	13.3	0.06	<0.50		bd
Argetsinger	2-01-84	-	-	85	632	<0.2	tr	18.0	0.09	a.50		tr
Keithahn	2-01-84	-	-	-	1000	-	-	-	-			
Hagerup	5-02-84	-	-	215	1720	0.2	tr		-			tr
Ramsey	3-22-84	-	167	2	2	<0.1	bd	13.7	1.12	<0.50		bd
Lundstrom	5-02-84	-	-	3	9	0.1	bd		-			tr
Palmer	5-03-84	-	224	9	44	<0.1	bd	24.0	0.82			?r
Beaver Springs	5-03-84	-	-	-	-	-		-	-			
Mendenhall 1390	5-03-84	-	-	1	1	<0.1	bd	5.6	1.14	<0.50		bd

Table 1. Preliminary geochemical analyses, Auke Bay - Mendenhall Peninsula, ordered by locality.

Site Name	Date Sampled	Map No.	As, ppb	TDS	SC (a)	Stable isotopes per mil 018	D
Olson	6-16-84	23-24	4	1364	1600	-	-98
U. of Juneau	6-16-84	23-14	9	1070	1450	-	-96
Bay View	6-14-84	23-01A	1	2086	2600	-	-94
Ghea	6-14-84	23-28	2	362	460	-	-97
Jones	b-19-84	23-05	4	390	450	-	-100
Dehardt	6-14-84	23-08	3	896	790	-	-98
Auke Bay	6-19-84	23-23	1	792	1000	-	-98
Trambitas	6-19-84	23-31	263	449	220		-93
Coates	6-20-84	23-41	78	,357	310		-95
Auke Creek	6-15-84	23-44		-	21		-96
Bay Creek	6-15-84	23-45			44	-	-96
Lake Creek	6-15-84	23-46	-	-	21	-	-99
Karenin	J-13-84	35-13	2	504	600	-13.4	-96
Thomason	3-13-84	35-24	1	403	410	-13.3	-95
Houlihan	3-22-84	35-15	2	662	775		
Hursch	3-14-84	35-10	14	223	215	-13.0	-95
Watts	2-02-84	35-28	4	153	320		
Clasby	i-Ok-d-4	35-05	1	495	590	-12, b	-93
Lamonica	5-02-84	35-53	<1	601	760	-12.7	-95
Meilke	2-01-84	35-38	2	671	900		-
Nash	5-03-84	35-48		14	450	-13.3	-96
Buckley	5-02-84	35-12		77	420		
Mc Vey	3-22-84	35-39	3	754	790	-13.0	-98
Cummings	2-07-84	35-09	46	204	470		
Johnson	5-02-84	35-52			420		
Bradley	3-14-84	35-03	24	400	430	-12.6	-95
Argetsinger	2-01-84	35-02	7	1201	1650		
Keithahn	2-01-84	35-11		-	2500		
Hagerup	5-02-84	35-08		1935	4500	-12.5	-90
Ramsey	3-22-84	35-20	7	155	175	-12.4	-91
Lundstrom	5-02-84	35-33		12	320	-	
Palmer	5-03-84	35-43	9	366	400	-13.5	-96
Beaver Springs	5-03-84	35-55		-	32	-12.3	-92
Mendenhall 1390	5-03-84	35-54	<1	17	15	-13.1	-94

Table 2. Preliminary geochemical analyses, Auke Bay - Mendenhall Peninsula, ordered by type.

Site Name	Date Sampled	Hap	No,	Well Type	Depth, ft	T	pH	(a!	Cations, ppm Na	K	Ca	Mg	Li	Sr
Thomason	3-13-84	35-24		1	216	5	8.7		154	0.4	1.5	1.1	0002	0.
Karenin	3-13-84	35-13		1	85	5	9.3		199	3.8	1.4	1.2	0.01	0.
Houlihan	3-22-84	35-15		1	2b0	5			276	0.8	2.7	2.5	0.02	-
Clasby	3-M-64	35-05		1	150	14	8.9		185	0.4	2.8	1.7	0'02	0.
Meilke	2-01-84	35-38		1	220	9			277	2.5	4.2	2.6	0.03	-
Ghea	b-14-04	23-28		2	73	7	8.4		139	8.5	5.2	2.9	0.02	0.
Olson	b-1 b-94	23-24		2	275	7	8.1		352	2.7	2b.0	9.2	0.08	3.
Dehardt	6-14-84	23-08		2	290	12	7.5		179	6.1	29.3	15.5	0.05	2.
Auke Bay	6-19-84	23-23		2	202	10	8.0		230	4.9	29.3	9.7	0.07	2.
U. of Juneau	6-16-84	23-14		2	227	11	8.4		299	9.1	20.4	19.3	0.06	1.
Jones	6-19-84	23-05		2	145	7	7.7		93	6.5	29.3	8.0	0.01	0
Bay View	6-14-84	23-01A		2	90	10	7.3		440	20.1	147.0	103.0	0.11	7
Hursch	3-14-84	35-10		3a	200	7	7.6		40	0.9	31.5	1.2	ø.01	0
Bradley	3-14-84	35-03		3a	95	8	7.9		98	5.0	24.0	14.8	0.03	1
Watts	2-02-84	35-28		3a	200	7			84	1.6	19.8	6.5	0.01	-
Cummings	i-07-94	35-09		3a	212	6			171	1.2	16.2	8.5	0.02	-
Coates	b-20-84	23-4:		3b		8	7.5		29	4.1	37.5	19.2	0.02	0
Trambitas	b-19-84	23-31		3b	109	9	7'7		18	2.6	31.5	10.5	0.01	0
Ramsey	3-22-84	35-20		3c	202	7	6.7		13	0.5	35.8	6.5	0.01	0
Mc Vey	3-22-84	35-39		3c	89	12	7.2		40	7.7	140.0	33.4	0.06	1
Mendenhall 1390	5-03-84	35-54		3c		5	5.4		1	<0.5	3.5	1.0	<0.01	<0
Lamonica	5-02-84	35-53		3c	200	9	7.3		17	4.6	166.0	17.0	0.04	1
Palmer	5-03-84	35-43		3c	93	7	7.5		44	3.7	47.0	25.8	0.02	0
Argetsinger	2-01-84	35-02		3c	115	7			132	24.0	211.0	92.0	0.09	-
Nash	5-03-84	35-48			80	6						-		-
Keithahn	2-01-84	35-32			92	9						-		-
Hagerup	5-02-84	35-08			129	8						-		-
Johnson	5-02-84	35-52			475	9						-		-
Lundstrom	5-02-84	35-33				10						-		-
Buckley	5-02-84	35-12			87	6						-		-
Auke Creek	6-15-84	23-44				14						-		-
Bay Creek	6-15-84	23-45				9						-		-
Seaver Springs	5-03-84	35-55				4						-		-
Lake Creek	6-15-84	23-46				3						-		-

(a) Measured at well water temperature.

Table 2. Preliminary geochemical analyses, Auke Bay - Mendenhall Peninsula, ordered by type.

Site Name	Date Sampled	Anions, ppm CO3	HCO3	SO4	Cl	F	Br	Other, ppm SiO2	Fe	B	NH4	NO3
Thomason	3-13-84	6.0	346	57	4	0.7	bd	7.5	0.12	<0.50	-	bd
Karenin	3-13-84	28.0	506	35	4	1.2	bd	6.2	0.18	0.83	-	bd
Houlihan	3-22-84	-	-	345	24	1.0	bd	7.3	-	0.80	-	bd
Glasby	J-04-84	6.0	283	109	40	0.8	bd	7.7	0.15	<0.50	-	bd
Meilke	2-01-84	-	-	214	157	0.6	bd	10.8	-	0.50	-	tr
Ghea	6-14-84	2.5	345	15	8	0.7	bd	8.2	0.10	<0.05	-	0.
Olson	*b-l t-84*	-	143	788	98	2.7	bd	6.6	0.09	-	-	tr
Dehardt	*b-14-54*	-	277	235	78	1.9	bd	9.0	0.12	<0.50	-	0.
Auke Bay	6-19-84	-	328	262	80	2.8	bd	7.8	0.04	0.60	-	tr
U. of Juneau	6-16-84	1.5	269	396	166	0.3	tr	15.0	0.20	-	-	bd
Jones	b-19-84	-	286	39	53	0.1	bd	14.0	1.08	<0.50	-	bd
Bay View	*b-14-04*	-	241	292	944	0.3	tr	12.5	0.22	<0.50	-	0
Hursch	3-14-84	-	210	19	2	<0.1	bd	10.5	0.23	<0.50	-	bd
Bradley	3-14-84	-	334	57	22	0.2	bd	13.3	0.08	<0.50	-	bd
Watts	2-02-84	-	-	22	2	0.1	bd	12.7	-	<0.50	-	bd
Cummings	2-07-84	-	-	9	13	0.4	bd	19.0	-	<0.50	-	bd
Coates	6-20-84	-	260	35	10	.0	bd	15.0	0.69	<0.50	-	tr
Trambitas	6-19-84	-	204	10	2	<0.1	bd	10.8	0.23	0.60	-	bd
Ramsey	3-22-84	-	167	2	2	<0.1	bd	13.7	1.12	<0.50	-	bd
Mc Vey	3-22-84	-	410	295	9	0.4	bd	26.0	1.28	<0.50	0.4	bd
Mendenhall 1390	5-03-84	-	7	1	1	<0.1	bd	5.6	1.14	<0.50	-	bd
Lanonica	5-02-84	-	334	62	153	tr	bd	16.0	1.02	<0.50	-	bd
Palmer	5-03-84	-	324	9	44	<0.1	bd	24.0	0.82	-	-	tr
Argetsinger	2-01-84	-	-	85	632	<0.2	tr	18.0	0.09	<0.50	-	tr
Nash	5-03-84	-	-	12	2	0.8	bd	-	-	-	-	tr
Keithahn	2-01-84	-	-	-	1000	-	-	-	-	-	-	-
Hagerup	5-02-84	-	-	215	1720	0.2	tr	-	-	-	-	tr
Johnson	5-02-84	-	-	34	17	0.1	bd	-	-	<0.50	-	tr
Lundstrom	5-02-84	-	-	3	9	0.1	bd	-	-	-	-	tr
Buckley	5-02-84	-	-	73	4	0.3	bd	-	-	-	-	bd
Auke Creek	6-15-84	-	-	-	-	-	-	-	-	-	-	-
Bay Creek	6-15-84	-	-	-	-	-	-	-	-	-	-	-
Seaver Springs	5-03-84	-	-	-	-	-	-	-	-	-	-	-
Lake Creek	6-15-84	-	-	-	-	-	-	-	-	-	-	-

(a) Measured at well water temperature.

Part 3

Table 2. Preliminary geochemical analyses, Auke Bay - Mendenhall Peninsula, ordered by type.

Site Name	Date Sampled	Hap No,	Type	Well Depth ft	As, ppb	TDS	SC (a)	Stable isotopes per mil O18	D
Thomason	3-13-84	35-24	1	216	1	403	410	-13.3	-95
Karenin	3-13-84	35-13	1	85	2	504	600	-13.4	-96
Houlihan	3-22-04	35-15	1	260	2	662	775	-	-
Glasby	3-04-84	35-05	1	150	1	495	590	-12.6	-93
Meilke	2-01-84	35-38	1	220	2	671	900	-	-
6hea	6-14-84	23-28	2	73	2	362	460	-	-97
Olson	b-16-84	23-24	2	275	4	1364	1600	-	-98
Dehardt	b-14-84	23-08	2	290	3	696	790	-	-98
Auke Bay	6-19-84	23-23	2	202	1	792	1000	-	-98
U. of Juneau	b-lb-04	23-14	2	227	9	1070	1450	-	-96
Jones	b-19-64	23-05	2	145	4	390	450	-	-100
Bay View	6-14-84	23-01A	2	90	1	2086	2600	-	-94
Hursch	3-14-84	35-10	3a	200	14	223	215	-13.0	-95
Bradley	3-f4-84	35-03	3a	95	24	400	430	-12.6	-95
Watts	2-02-84	35-28	3a	200	4	153	320	-	-
Cummings	2-07-84	35-09	3a	212	46	284	470	-	-
Coates	6-20-84	23-41	3b	-	78	357	310	-	-95
Trambitas	6-i 9-84	23-31	3b	109	263	449	220	-	-93
Ramsey	3-22-84	35-20	3c	202	7	155	175	-12.4	-91
Mc Vey	J-22-84	35-39	3c	89	3	754	790	-13.0	-98
Mendenhall 1390	5-03-84	35-54	3c	-	<1	17	15	-13.1	-94
Lamonica	5-02-84	35-53	3c	200	<1	601	760	-12.7	-95
Palmer	5-03-84	35-43	3c	93	9	366	400	-13.5	-96
Argetsinger	2-01-84	35-02	3c	115	7	1201	1650	-	-
Nash	5-03-84	35-48	-	80		14	450	-13.3	-96
Keithahn	2-01-84	35-32	-	92		-	2500	-	-
Hagerup	5-02-84	35-08	-	129		1935	4500	-12.5	-90
Johnson	5-02-84	35-52	-	475		-	420	-	-
Lundstrom	5-02-84	35-33	-	-		12	320	-	-
Buckley	5-02-84	35-12	-	87		77	420	-	-
Auke Creek	b-15-64	23-44	-	-		-	21	-	-96
Bay Creek	6-15-84	23-45	-	-		-	44	-	-96
Seaver Springs	5-03-84	35-55	-	-		-	32	-12.3	-92
Lake Creek	6-15-84	23-46	-	-		-	21	-	-99

(a) Measured at well water temperature.

Table 3. Concentration of chloride, ppm. in well waters Prom Mendenhall peninsula and Auke Bay.

Site Name	Date Sampled	Map No.	Cl	Bell Depth, ft
Hagerup	5-02-84	35-08	1720	129
Kei thahn	2-01-84	35-32	1000	92
Bay View	b-14-84	23-01A	944	90
Argetsinger	2-01-84	35-02	632	115
U. of Juneau	6-l 6-84	23-14	166	227
Meilke	2-01-84	35-38	157	220
Lamonica	S-02-84	35-53	153	200
Olson	6-16-84	23-24	98	275
Auke Bay	6-19-84	23-23	80	202
Dehardt	6-14-84	23-08	78	290
Jones	6-19-84	23-05	53	145
Palmer	5-03-84	35-43	44	93
Clasby	3-04-84	35-05	40	150
Aoulihan	3-22-84	35-15	24	260
Bradley	3-14-84	35-03	22	95
Johnson	5-02-84	35-52	17	475
Cummings	2-07-84	35-09	13	212
Coates	6-20-84	23-41	10	
Lundstrom	5-02-84	35-33	9	
Mc Vey	3-22-84	35-39	9	89
Ghea	6-14-84	23-28	3	73
Thomason	3-13-84	35-24	4	216
Karenin	j-13-84	35-13	4	85
Buckley	S-02-84	35-12	4	87
Watts	2-02-84	35-28	2	200
Hursch	J-14-84	35-10	2	200
Ramsey	S-22-84	35-20	2	202
Trambi tas	6-19-34	23-31	2	109
Nash	S-03-84	35-48	2	80
Hendenhall 1390	5-03-84	35-54	1	
Bay Creek	b-15-84	23-45		
Seaver Springs	S-03-84	35-55		-
Lake Creek	6-15-84	23-46	-	
Auke Creek	6-15-84	23-44	-	

Table 4. Concentration of arsenic, **p p b ,** in well waters from Mendenhall Peninsula and **Auke** Bay.

Site Name	Date Sampled	Map No.	As, ppb	Well Depth, ft
Trambi tas	6-19-84	**23-31**	**263**	109
Coates	6-20-84	**23-41**	**73**	
Cummings	z-07-34	**35-09**	**46**	**212**
Bradley	3-14-84	**35-03**	**24**	**95**
Xursch	**3-14-34**	35-10	**14**	**200**
U. of Juneau	b-lb-84	23-14	**9**	**227**
Palmer	**5-03-34**	**35-43**	**9**	**93**
Ramsey	3-22-84	35-20	**7**	**202**
Argetsinger	2-01-84	**35-02**	**7**	115
Jones	**b-19-84**	**23-05**	**4**	**145**
Ratts	2-02-84	**35-28**	**4**	**200**
Olson	**b-lb-84**	**23-24**	**4**	**275**
Dehardt	**b-14-84**	23-08	**3**	**290**
MC Vey	**3-22-84**	**35-39**	**3**	**39**
Karenin	**3-13-84**	**35-13**	2	**35**
Houlihan	**3-22-34**	35-15	2	**260**
Meilke	**2-01-84**	**35-38**	2	**220**
Ghea	**6-14-84**	23-28	2	**73**
Clasby	**3-04-84**	**35-05**		150
Bay **View**	**b-14-84**	23-01A		**90**
Thomason	**3-13-84**	**35-24**		216
Auke Bay	**b-19-84**	**23-23**	1	**202**
Kei thahn	**2-01-84**	**35-32**		**92**
Nash	**5-03-84**	**35-48**	-	**80**
Buckley	**5-02-84**	**35-12**	-	**87**
Lundstrom	**5-02-84**	**35-33**	-	
Lake Creek	**6-15-84**	**23-46**	-	
Johnson	**5-02-84**	**35-52**	-	**475**
Auke Creek	**6-15-84**	**23-44**	-	
Bay **Creek**	**b-l 5-84**	**23-45**	-	-
Seaver Springs	5-03-84	**35-55**		
Hagerup	**S-02-84**	**35-08**	-	**129**
Lamonica	**S-02-84**	**35-53**	<1	**200**
Hendenhall 1390	**S-03-84**	**35-54**	<1	

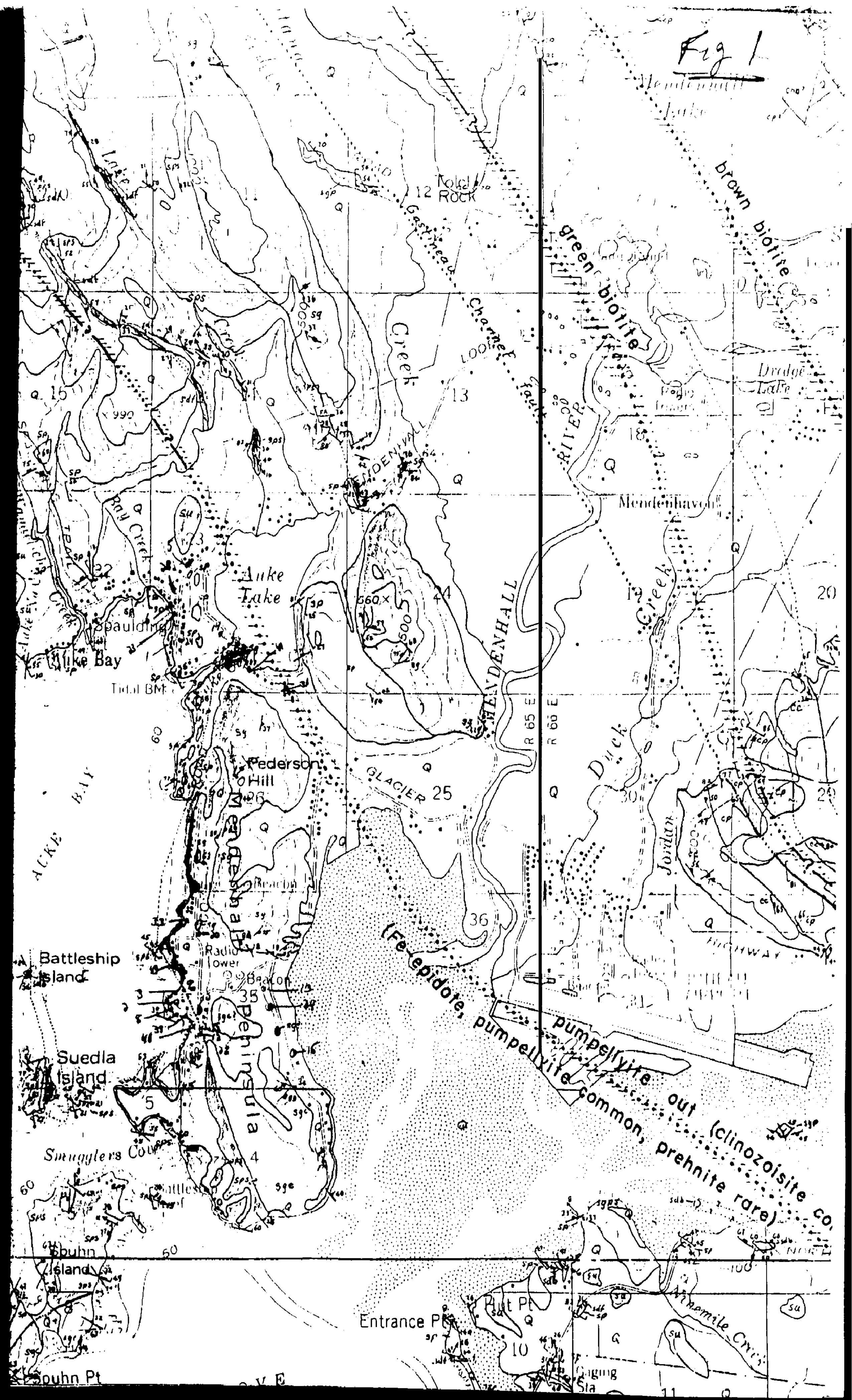
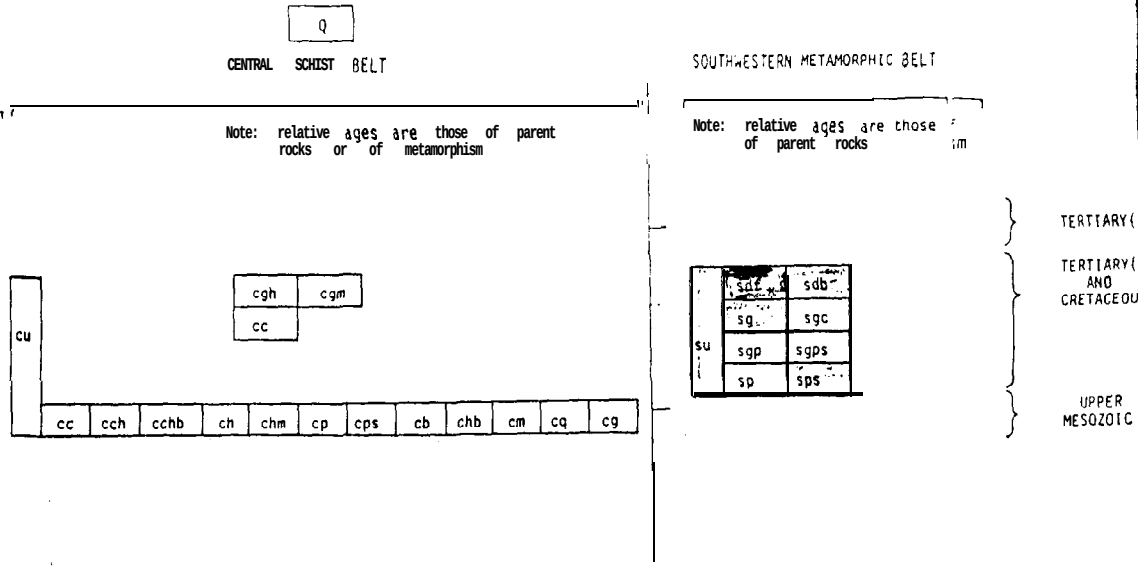

brown biotite
green biotite
(Fe-epidote, pumpellyite common, prehnite rare)
pumpellyite out (clinozoisite co
Gastineau Channel fault
Auke Lake
Auke Bay
Spaulding
Pederson Hill
Mendenhall Peninsula
MENDENHALL
Mendenhall
GLACIER
RIVER
Duck Creek
Jordan
Battleship Island
Suedla Island
Smugglers Cove
Entrance Pt
Spuhn Pt
Spuhn Island
Radio Tower
Beacon
Tidal BM
Tidal Rock
Creek
TRAIL
Dredge Lake
Gaging Sta
R 65 E
R 66 E

Fig 1

MISCELLANEOUS
FIELD STUDIES MAP MF 527

1.40

CORRELATION OF MAP UNITS



DESCRIPTION OF MAP UNITS

Q SURFICIAL DEPOSITS--Undifferentiated glacial, alluvial, colluvial, marine, and glaciomarine materials; see A. 0. Miller (1972) for detailed descriptions and maps.

Southwestern metamorphic belt

(southwest of Gastineau Channel and Montana Creek)

su METAMORPHIC ROCKS, UNDIFFERENTIATED

sdf METAFELSITE--Dike and sill-like bodies.

sdb METABASALT, METADIORITE, AND METAGABBRO--Dikes, sills, end other small Intrusive bodies.

sg GREENSTONE AND GREENSCHIST--Chiefly augite-rich metatuff, originally basaltic to andesitic; In places mixed with metagraywacke, argillite, or slate. Cliff former.

sgc GREENSTONE AND METACONGLOMERATE--Mixed and undifferentiated rocks.

sgp GREENSTONE AND PELITIC ROCKS--Mixed and undifferentiated rocks.

sgps GREENSTONE, METAPELITIC ROCKS, AND METASANDSTONE--Mixed and undifferentiated rocks. Major lithologies of unit differentiated on Table Top Mountain, Douglas Island.

sp PELITIC ROCKS--Mostly argillite and slate, locally phyllite.

sps PELITIC ROCKS, METASANDSTONE, AND METASILTSTONE--Chiefly dark, volcanic-derived metasedimentary rocks, mixed and undifferentiated.

Central schist belt

(Between Gastineau Channel and Western front of main gneiss belt between Lemon Creek Glacier and Stroller White Mountain)

cu METAMORPHIC ROCKS, UNDIFFERENTIATED

cgh HOMOGENEOUS GRANITIC GNEISS--Chiefly biotite- and hornblende-bearing quartz dioritic gneiss (orthogneiss) of Mount Juneau pluton. Commonly contains minor amounts of garnet.

cgm MIGMATITE--Heterogeneous mixture of schist and granitic gneiss.

cc CHLORITE SCHIST AND GREENSCHIST--Generally well foliated, but Includes greenstone and semischist locally near Gartineau Channel and Montana Creek,

cch CHLORITE SCHIST. GREENSCHIST, AND HORNBLENDE SCHIST--Mixed and undifferentiated rocks.

cchb CHLORITE-, HORNBLENDE-, AND BIOTITE-BEARING SCHIST--Mixed and undifferentiated rocks.

[illegible] SCHIST, AMPHIBOLITE, AND METAGABBRO

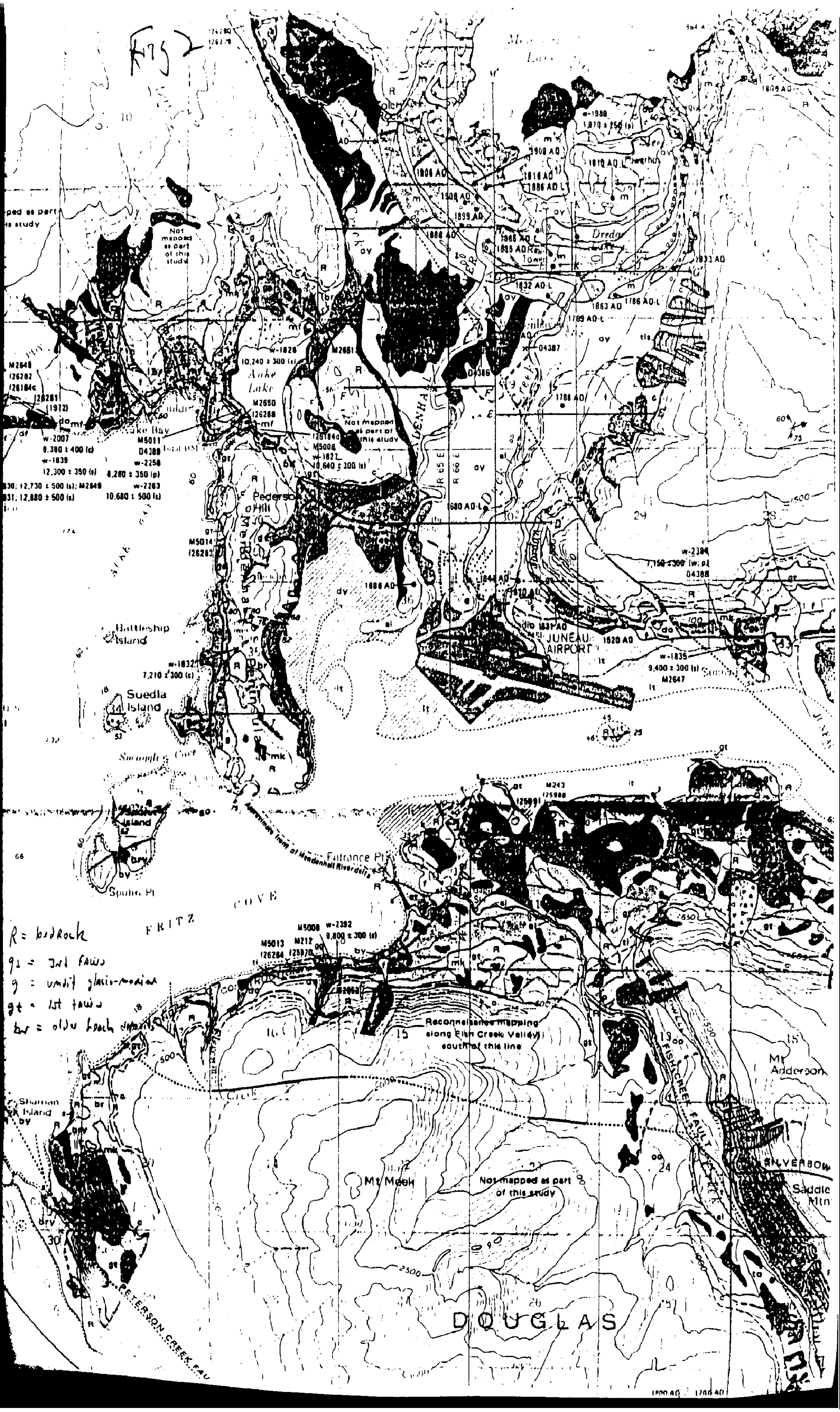


Fig 2
Not mapped as part of this study
Auke Lake
Auke Bay
Pederson Hill
Battleship Island
Suedla Island
Smuggler's Cove
Spuhn Pt
FRITZ
COVE
Fritz Cove
Entrance Pt
Approximate front of Mendenhall Riverdelta
JUNEAU AIRPORT
Dredge Lake
MENDENHALL
Reconnaissance mapping along Fish Creek Valley south of this line
FISH CREEK FAULT
Mt Meek
Mt Anderson
Saddle Mtn
SILVERBOW
DOUGLAS
PETERSON CREEK FAULT
Shaman Island
R = bedrock
gl = 2nd fauna
g = undiff glacio-marine
gt = 1st fauna
bv = older beach deposits
w-1988
1,970 ± 250 (s)
w-1826
10,240 ± 300 (s)
w-1827
10,640 ± 300 (s)
w-2007
8,380 ± 400 (c)
w-1839
12,300 ± 350 (s)
w-2258
8,280 ± 350 (p)
w-2263
10,680 ± 500 (s)
w-1832
7,210 ± 300 (c)
w-1835
9,400 ± 300 (s)
w-2392
9,800 ± 300 (s)
w-2384
7,150 ± 300 (w; p)
1886 AD
1910 AD
1908 AD
1899 AD
1832 AD-L
1863 AD
1786 AD-L
1789 AD-L
1680 AD-L
1520 AD

Fig 3

Avoke_Bay Sect 23
& Marden hall _ Peninsula
_Sect_35_

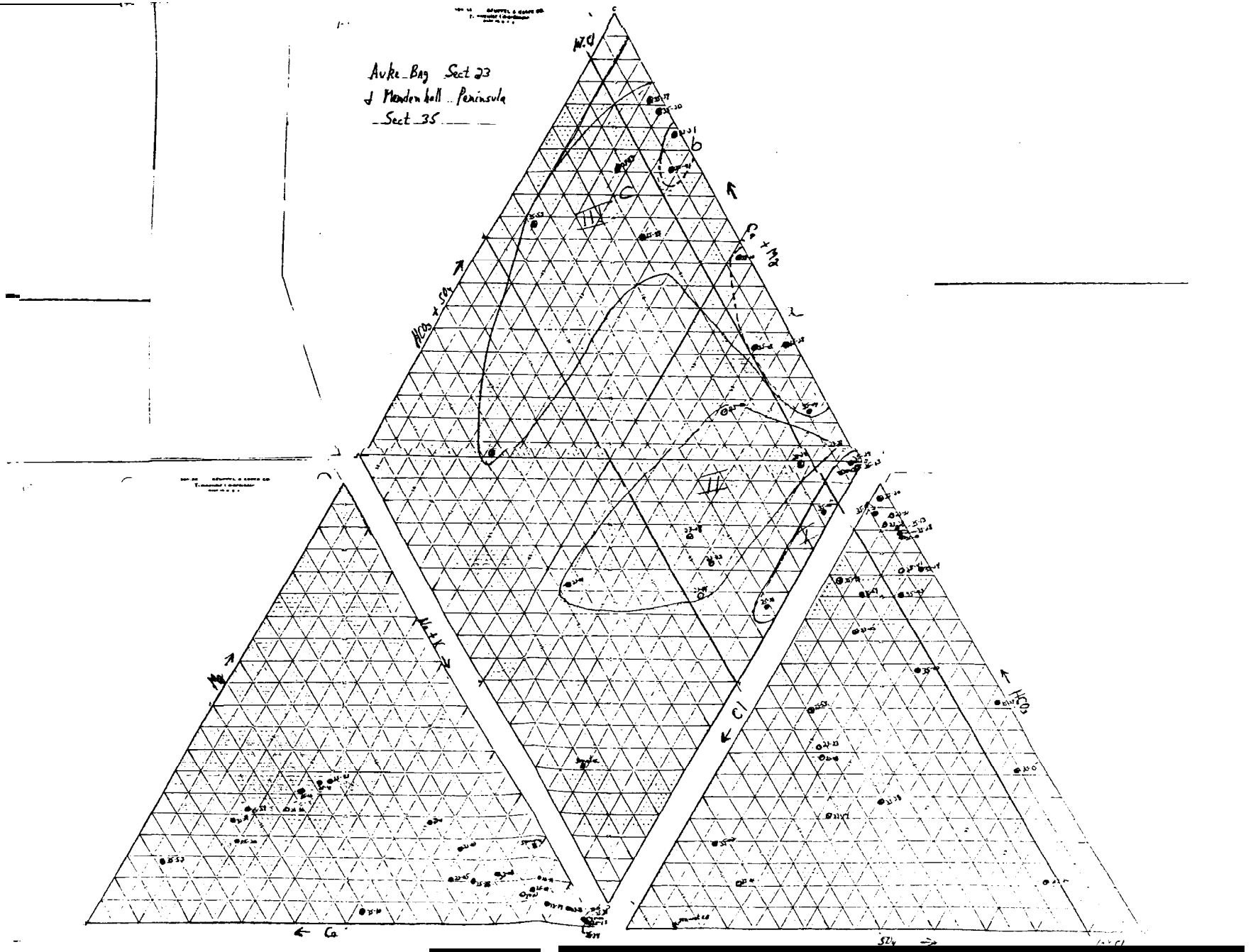
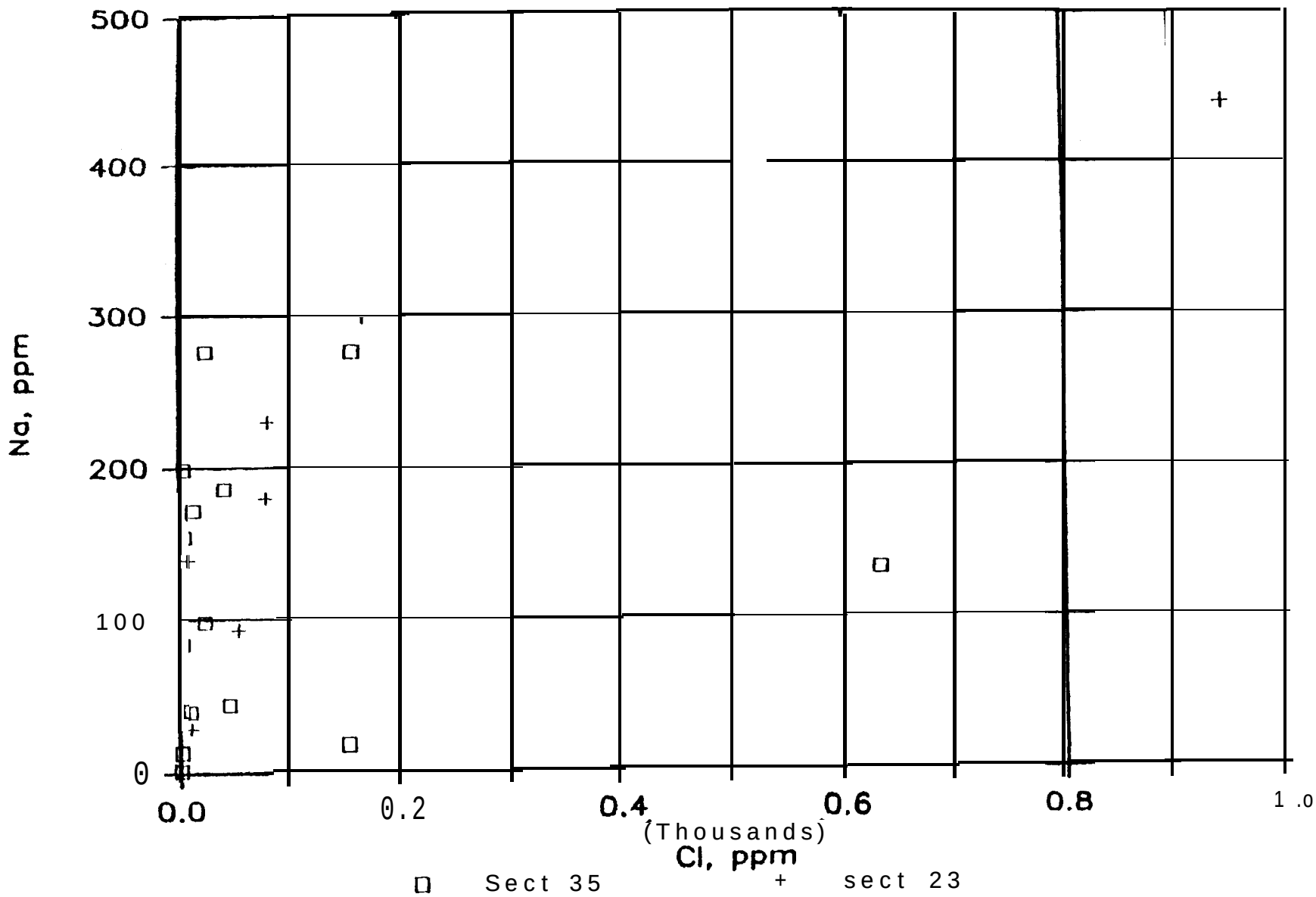


Fig 4


500
400
300
200
100
0
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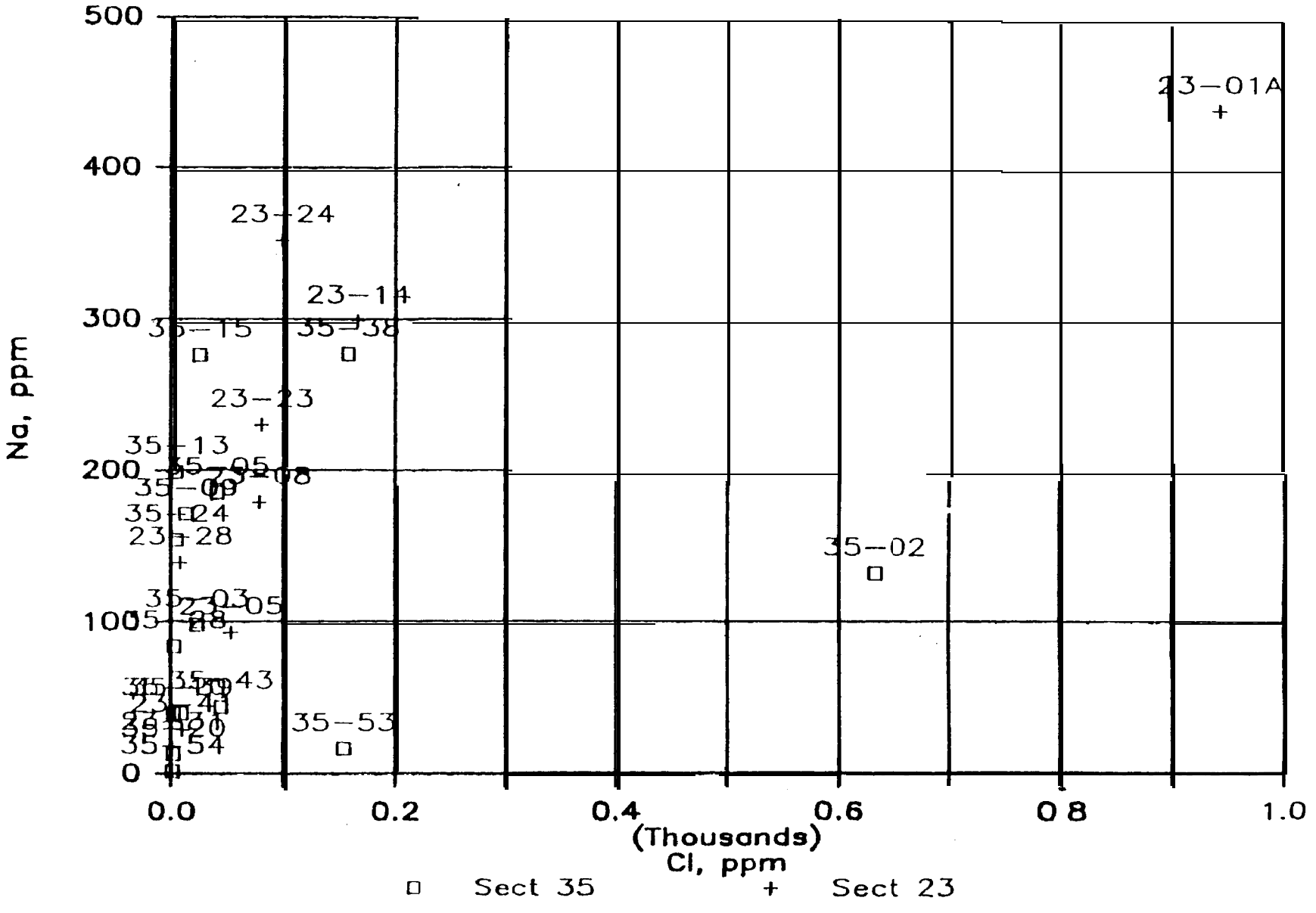
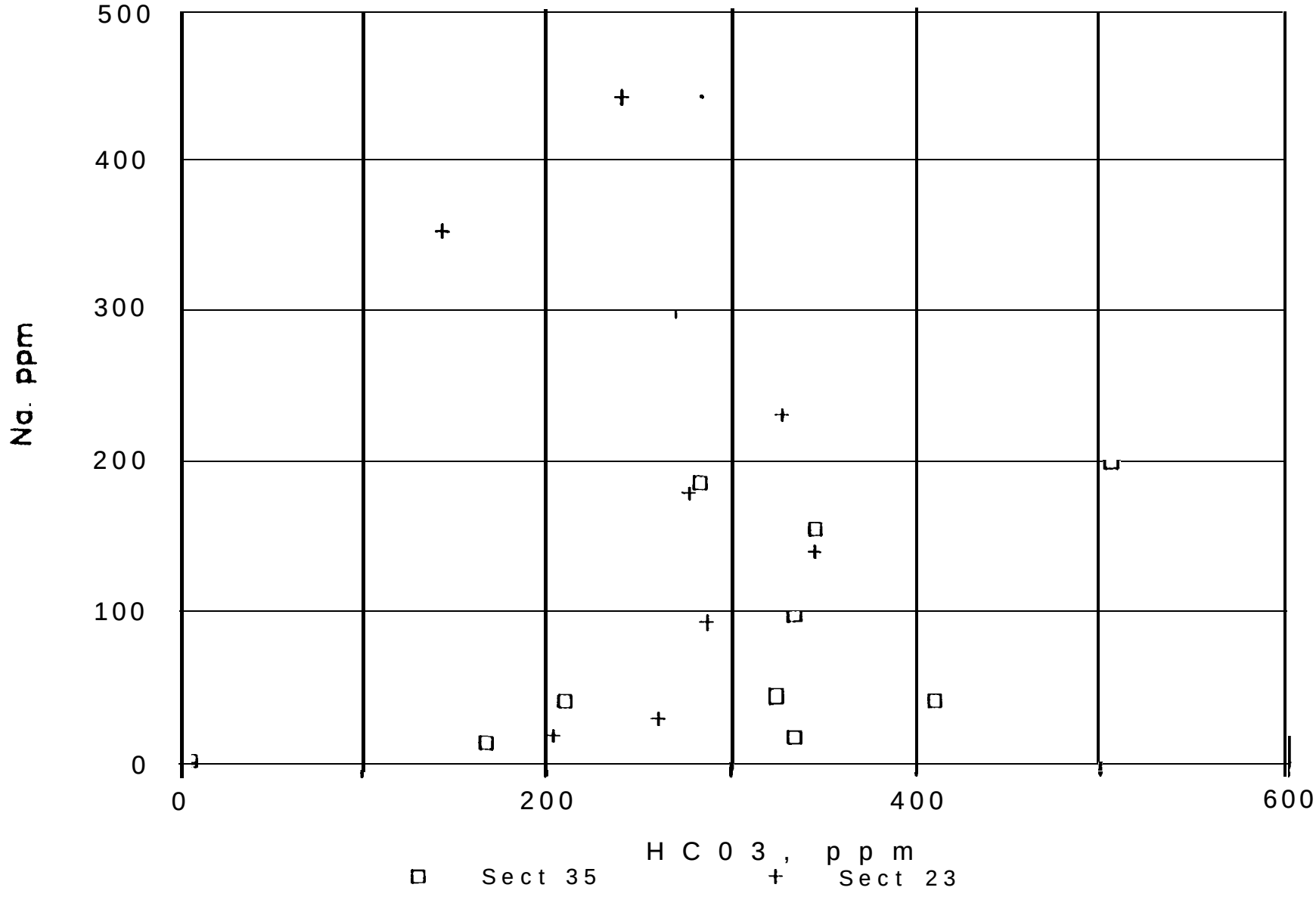
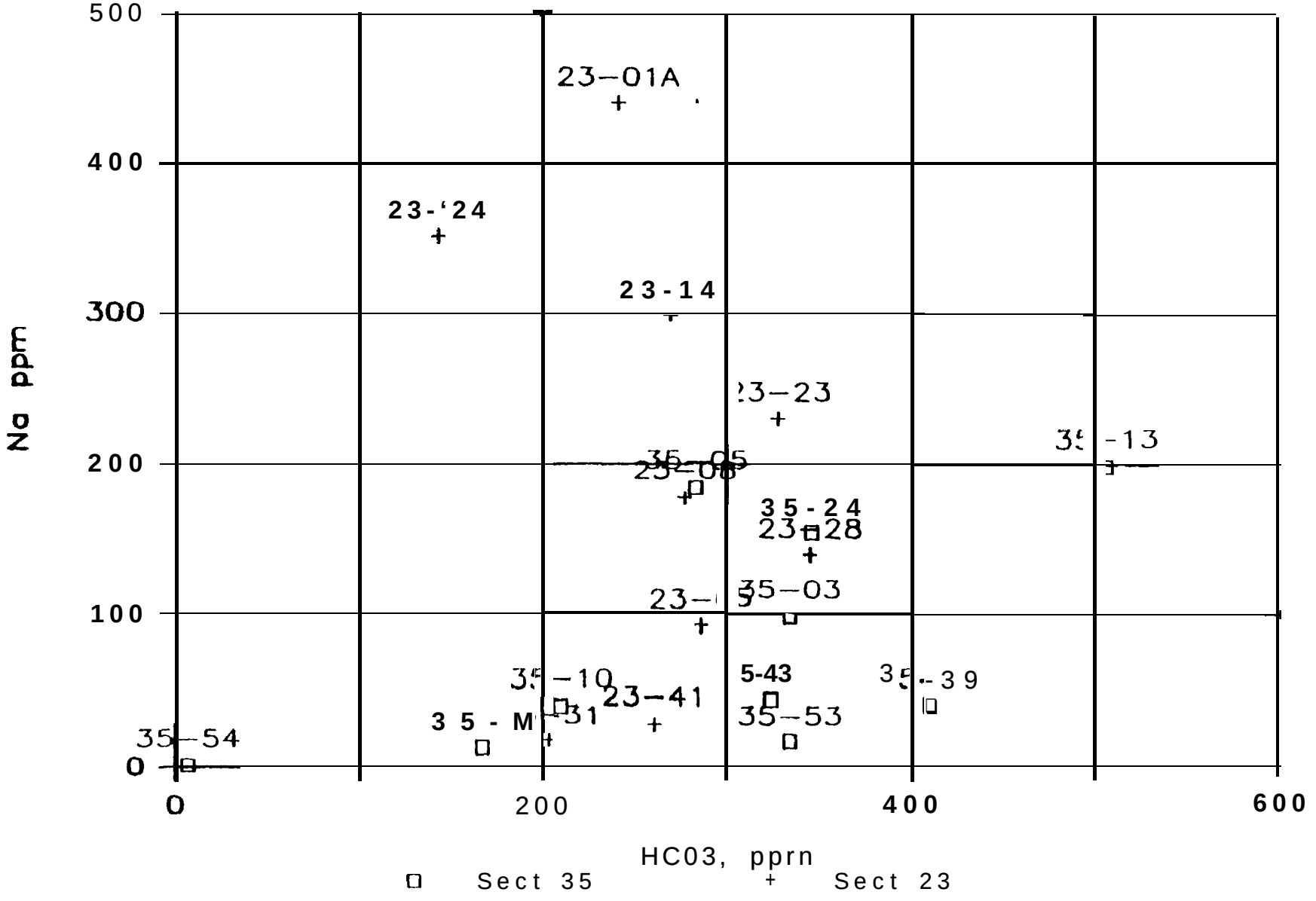
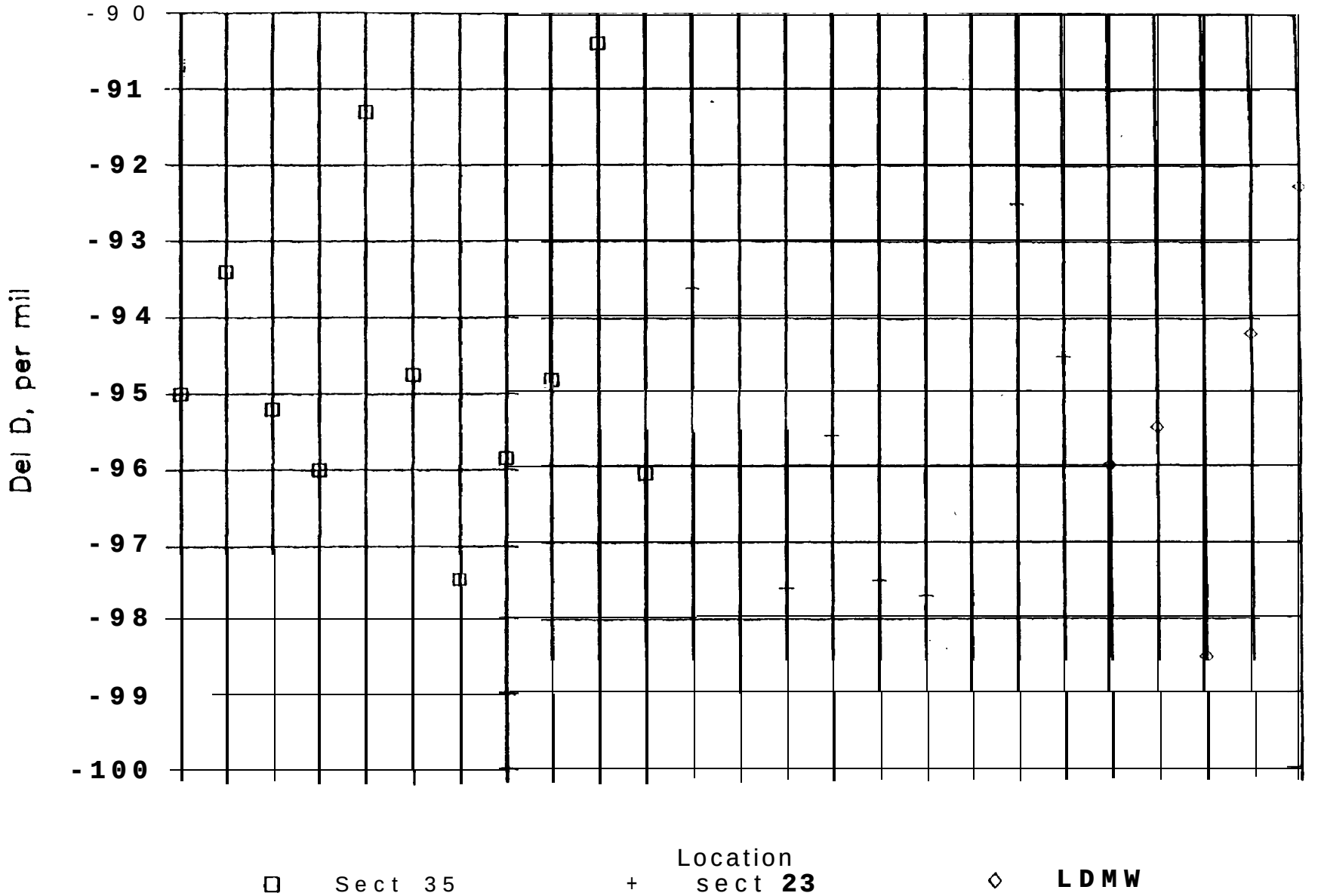
0.2
0.4
0.6
0.8
1.0
(Thousands)
Cl, ppm
Sect 35
sect 23


500
400
300
200
100
0
Na, ppm
0.0
0.2
0.4
0.6
0.8
1.0
(Thousands)
Cl, ppm
23-01A
23-24
23-14
35-15
35-38
23-23
35-13
35-02
35-53
Sect 35
Sect 23


500
400
300
200
100
0
Na, ppm
0
200
400
600
HC03, ppm
Sect 35
Sect 23


500
400
300
200
100
0
Na ppm
23-01A
23-'24
23-14
23-23
35-13
35-05
23-08
35-24
23-28
35-03
23-
35-10
23-41
5-43
35-39
35-M31
35-53
35-54
0
200
400
600
HC03, pprn
Sect 35
Sect 23


-90
-91
-92
-93
-94
-95
-96
-97
-98
-99
-100
Del D, per mil
Location
Sect 35
sect 23
LDMW

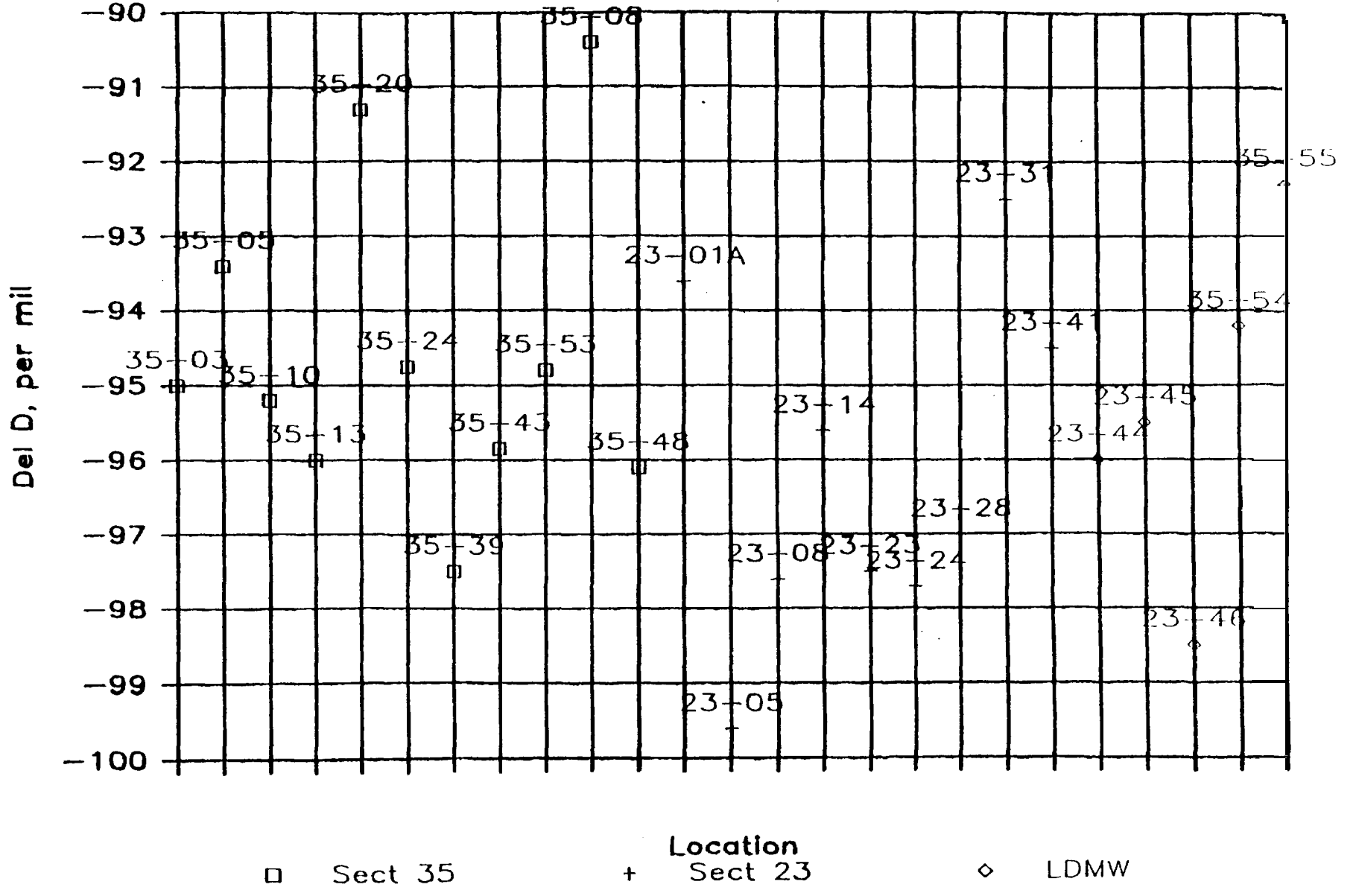
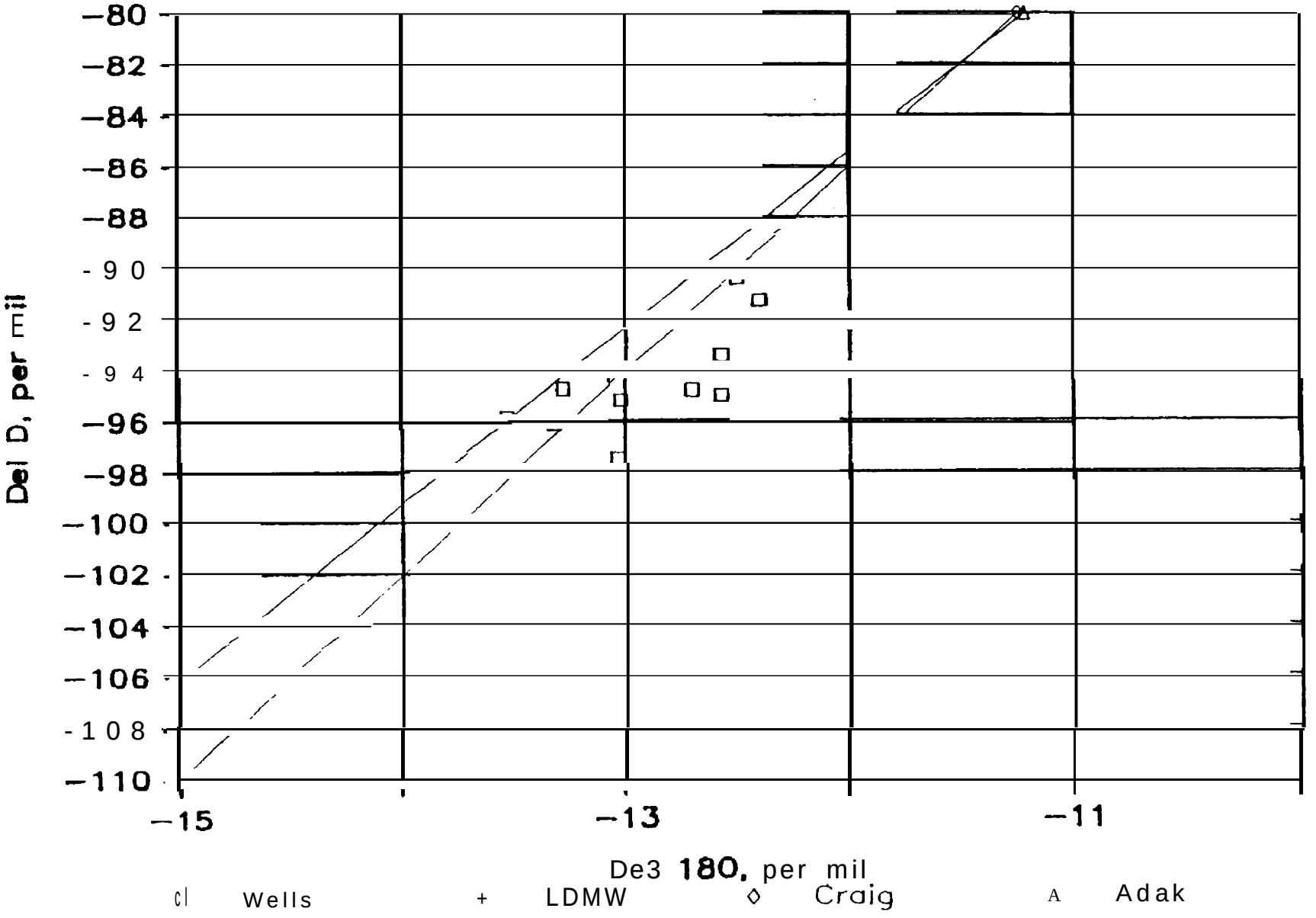
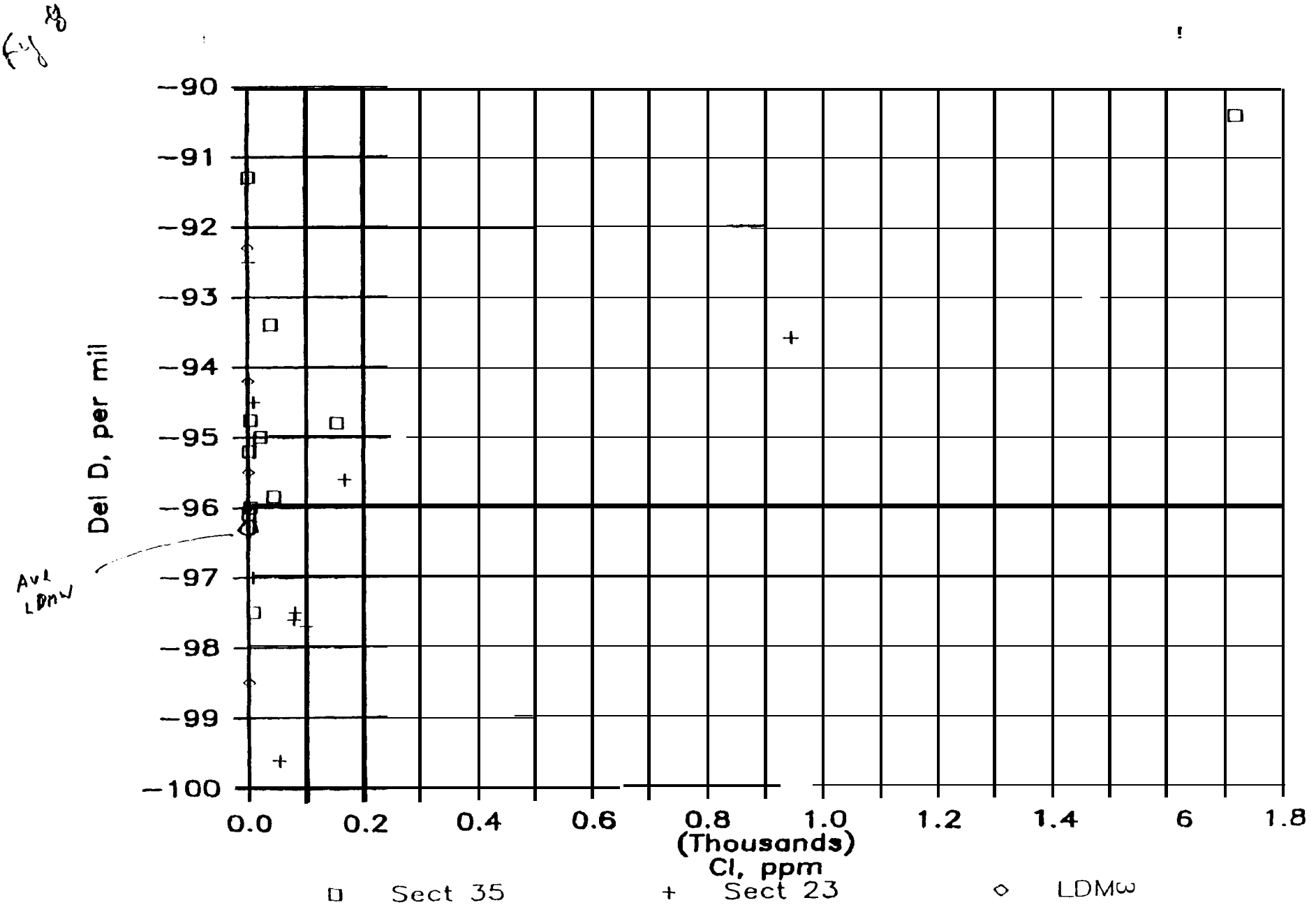

-90
-91
-92
-93
-94
-95
-96
-97
-98
-99
-100
Del D, per mil
35-08
35-20
35-05
23-01A
23-31
35-55
35-54
23-41
35-03
35-10
35-24
35-53
23-14
23-45
23-44
35-13
35-43
35-48
23-28
35-39
23-08
23-23
23-24
23-46
23-05
Location
Sect 35
Sect 23
LDMW

Fig 7


−80
−82
−84
−86
−88
- 9 0
- 9 2
- 9 4
−96
−98
−100
−102
−104
−106
- 1 0 8
−110
Del D, per Eil
−15
−13
−11
De3 180, per mil
Wells
LDMW
Craig
Adak


Del D, per mil
−90
−91
−92
−93
−94
−95
−96
−97
−98
−99
−100
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
6
1.8
(Thousands)
Cl, ppm
Sect 35
Sect 23
LDMω